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Reducing Dose In Coronary Computed Tomography Angiography (CCTA)

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What is CT?

- Computed tomography (CT) is the mechanism of creating cross-sectional tomographic planes of any part of the body
- Cross-sectional images generated can be reformatted in coronal, sagittal and axial planes

(Long, Rollins & Smith, 2016, p. 302)

What is CCTA?

- Coronary computed tomography angiography (CCTA) is a noninvasive imaging procedure to aid in diagnosis coronary artery disease (CAD)
- Appropriate for diagnosis and risk assessment in those with low to intermediate CAD risk

(Hamilton-Craig et al., 2020, p. 26)

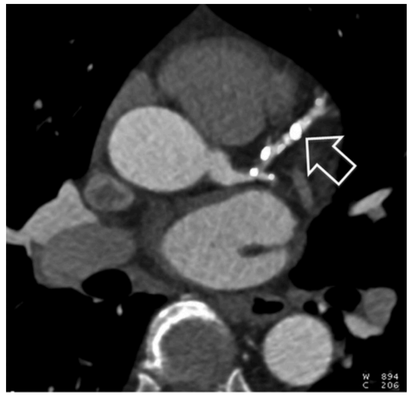

Image 1: Arrow pointing to calcified plaque in proximal left anterior descending coronary artery

(Renker et al., 2011, p. 394)

Dose Received From CCTA Exams

- CCTA studies average 15.7 millisieverts (mSv) of effective dose, some studies reaching up to 20 mSv or more (Hamilton-Craig et al., 2020, p. 26).
- Risk of exposure-induced cancer death (REID) was 1 in 746 men and 1 in 508 women undergoing CCTA exams
- REID values found to be considerably higher in younger women

(Mahmoodi & Chaparian, 2019, p. 1134)

Electrocardiogram (ECG)-Triggered Prospective Gating

- Associated with lowest-dose CCTA scans
- Monitors patient's heart rate and scans during most useful parts of the cardiac cycle
  - Typically time elapsed between two successive R waves of QRS signal on ECG; R-R interval
- Prospective gating activates tube to scan only during predetermined points in the cardiac cycle
- Accounts for an approximate 67% to 72% decrease in radiation dose during CCTA exams (Corbett, 2020, p. 405)

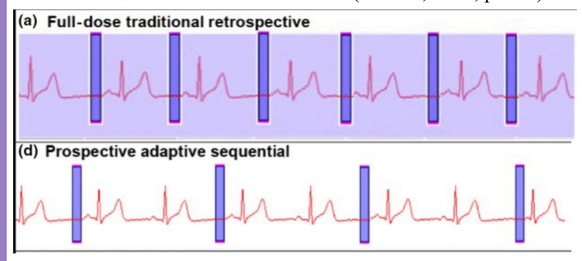

Image 2: Radiation exposure during retrospective gating (tube active throughout cardiac cycle) and prospective gating

(Hamilton-Craig et al., 2020, p. 27)

Proper Use & Limitations of Prospective Gating

- Effective prospective gating requires regular, slow heart rate, typically 50-65 beats per minute (BPM)
- Patients whose heart rate exceeds 70 bpm do not qualify for prospective gating
  - Increased risk of motion artifact, resulting in repeating entire scan & increased patient dose (Fornell, 2019, p. 27)

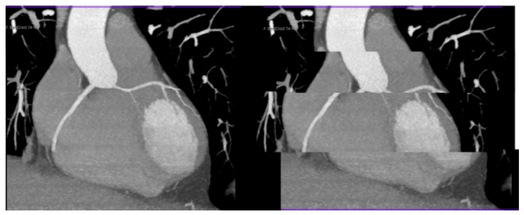

Image 3: Effect of heart rate on prospectively gated CCTA scan

(Hamilton-Craig et al., 2019, p. 28)

Reducing Tube Potential

- Studies have shown the most important factor of controlling dose is adjustment of x-ray tube voltage
- Due to contrast administration, typical tube voltage for CCTA exams around 120 kilovolts peak (kVp)
- Reducing tube potential from the standard 120 kVp to 80-100 kVp significantly reduced dose approximately 31% to 40%

(Fornell, 2019, p. 26; Hamilton-Craig et al., 2020, p. 31)

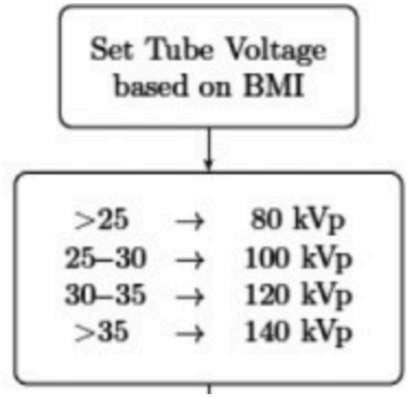

Image 4: Recommended tube voltage for patient's BMI

(Hamilton-Craig et al., 2020, p. 31)

Proper Use & Limitations of Tube Potential Reduction

- Lowering kVp lowers radiation dose while simultaneously increases image noise
- Selecting tube potential involves a trade-off between image noise and dose
- Better suited for use on average-sized or smaller patients
  - Body mass index (BMI) < 30 kg/m^2
- Reducing tube potential on obese patients results in scans with inadequate image quality

(Corbett, 2020, p. 405; Fornell, 2019, p. 25)

Bolus Tracking

- Begins with a delay to allow contrast to get to target area, takes intermittent pictures of descending aorta until it reaches threshold of 120 Hounsfield Units (HU)
- Rapid contrast injection (4-6ml/sec) required in CCTA to highlight the arteries and vessels
- Bolus tracking (BT) used to estimate contrast arrival timing adding to approximately 12% of total dose
- Delay of 15 seconds and intermittent scans of 1-2s showed a significant reduction in dose without interfering with image quality

(Nishimura Matsumoto et al., 2018, pp. 313-314)

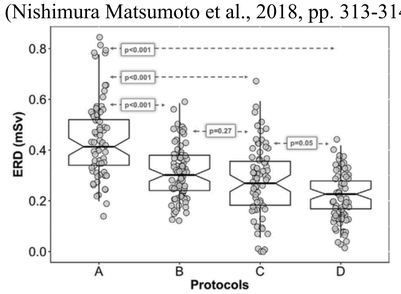

Image 5: BT effective radiation dose among protocols

(Nishimura Matsumoto et al., 2018, p. 314)

Conclusion

- CCTA is becoming an increasingly valuable diagnostic tool in diagnosing CAD
- Dose reduction techniques implemented during CCTA exams provide diagnostic quality scans while lowering dose to the patient
- Each method can be used independently or in conjunction with another
- Understanding the limitations and drawbacks of each method is extremely important

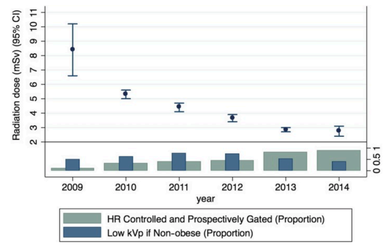

Image 6: Relationship between dose and proportion of patients receiving one or more reduction method

(Hamilton-Craig et al., 2020, p. 28)

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